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Psychological Effects of Lasers on the Battlefield: Issues and Ideas

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Lasers are a new dimension in battlefield lethality. While we have a great deal to learn about the prevalence of laser injuries on the Airland Battlefield, it is probable that the injury rate will be substantial. Unlike physical effects, psychological effects of lasers result from exposure as well as the possibility of exposure (suppression). The rate of physical injury will be correlated with psychological exposure effects, but suppressive effects may be considerably more numerous. Advances in protection technology, for example, might reduce the expected impact of exposure effects but increase the suppressive effects of laser employment. Thus, consideration of psychological effects must proceed as an integral part of the overall laser bioeffects program.

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Psychological Effects of Lasers on the Battlefield

INTRODUCTION

Lasers of many types and power output characteristics have been adapted for military application in recent years. The rapid integration of laser equipment into the force structure has brought with it increasing concern about the medical effects caused by the use of these lasers on the modern battlefield. The purpose of this paper is to examine some of the potential psychological effects of laser employment and injury on the AirLand battlefield, and discuss them in terms of the training strategies that will need to be developed to help counter this threat. Finally, proposed directions and methods of research will be addressed.

Before we consider the psychological effects of lasers, it will be profitable to briefly review some of the physical effects of exposure to lasers. The psychological effects can then be seen not only in the context of the physical injuries from lasers, but also in the broader context of the many other medical threats on the modern battlefield, which will include wounds due to bullet and fragment penetration, burns, perhaps chemical and ionizing radiation injury, disease, environmental injuries, and non-battle injuries.

Because of the virtually complete lack of reliable information concerning actual exposures to laser radiation under combat conditions, this analysis has relied on inferences and generalizations drawn from historical military sources, reports of civilian exposures, and consultation with a variety of experts.

LASER BIOEFFECTS

The threat of physical injuries from lasers is real and complex, and has been extensively studied and documented elsewhere (1). Lasers can cause eye injury, skin burns, and secondary burn effects resulting from the ignition of clothing. The risk of ocular injury is perhaps the greatest concern. The particular locus of injury within the eye depends on the wavelength of the laser used. The eye is particularly susceptible to injury from visible and near-infrared radiation because the radiation

collected is focused on the retina. Consequently, currently fielded rangefinders and designators can produce significant ocular injury at tactical ranges. High energy infrared lasers can burn the skin and cornea, resulting in immediate debilitation. Lasers operating in the ultraviolet may injure the cornea and lens. The shifting locus of damage with changes in wavelength is of course determined by the varying absorption properties of the different ocular structures. The amount of damage caused will depend on the power of the laser, the amount of area exposed, the amount of time that the area is exposed, and the temporal characteristics of the laser radiation. Repetitively pulsed or Q-switched lasers are much more pathogenic than continuous wave lasers.

Physiological Effects of Lasers

The range of injuries possible from laser exposure is extensive. Glare effects are disruptions in visual function that occur with exposure to visible lasers, and do not persist very long beyond the duration of the exposure itself. Flash effects (sometimes called "flashblindness" when severe) are disruptions in visual function that may persist well beyond the termination of the laser exposure that causes them, and may include afterimages, altered acuity, decreased sensitivity, and changes in color perception. A laser that is perceived as extremely bright may not produce any injury or perhaps only a temporary afterimage. Retinal burns occur at higher exposure levels, and are areas of physiological damage on the retina that may produce scotomas, permanent blind spots in the visual field. Very intense lasers may produce vitreous hemorrhage, a condition that results from the rupture of small blood vessels that supply the retina and the leaking of this blood into the substance that fills the eyeball. This blood will probably eventually be reabsorbed.

In summary, laser injuries may or may not be immediately apparent, may or may not produce blindness, and may or may not be permanent. However, serious injuries, such as vitreous hemorrhages, may be frequently encountered in the future.

PSYCHOLOGICAL EFFECTS OF LASERS

Any weapon has both direct effects, those which result from employment as intended, and indirect effects such as changes in behavior that result from the

possibility or threat of such employment. For example, the direct effect of the employment of high-explosive artillery shells is the destruction of targeted personnel and equipment. The indirect, behavioral effects of threatened use include the protective measures troops take to minimize the damage inflicted by these weapons (dispersion of personnel and equipment, construction of overhead cover) and concomitant degradation in military performance resulting from these measures (such as fatigue due to wearing steel helmet and flak vest). These are called suppressive effects.

In addition to the direct physical effects of a weapon, there may be direct psychological effects associated with its use. For example, at one time it was thought that continued exposure to the noise and concussion of artillery bursts could produce a psychophysiological disorder called "shell shock" (2). (This concept was later abandoned.) Effects of this type are called exposure effects.

Psychological effects of lasers can thus be thought of as indirect effects on uninjured soldiers that occur solely due to the employment or possibility of employment of lasers (suppressive effects) and direct effects that occur as a result of actual exposure to laser radiation (exposure effects), thus producing psychological or physiological injury. Significant military consequences can be expected from both categories of psychological effect.

Suppressive Effects of Laser Employment

What suppressive effects of laser employment can be expected on the modern battlefield? Perhaps the most obvious is the fear of losing one's vision. Blindness is a profound disability because vision is the human's primary means of spatial orientation, and without it, even locomotion is a risky affair. The helplessness most of us associate with blindness is indeed a frightening prospect, one that healthy young soldiers are eager to avoid.

Other suppressive effects are those related to wearing laser protective equipment. In fact, the willingness to use such equipment is a psychological variable that depends on the validity soldiers ascribe to doctrinal warnings about the laser threat. When such equipment is worn, it can be expected to degrade, to some degree, performance of target detection, recognition, acquisition, and engagement tasks. This degradation will

result in part from the strictly visual effects of the protective equipment, and has been the object of considerable research here at LAIR (3-5).

Another suppressive effect of possible laser employment is the alteration in duty performance caused by fear of laser exposure. Soldiers, either with or without laser protective equipment, may change their target search strategies, for example, in ways that they think might prevent them from becoming a laser casualty. Or, upon detection of an unusual light source, a soldier might break off tracking a target in response to his fear of eye injury. The factors governing behavior of this sort relate to beliefs about the nature of the threat, beliefs about the efficacy of the protective gear one is provided with, and beliefs about the efficacy of the evasive strategies one might adopt. For example, a soldier might close one eye to preserve monocular vision even if exposed to an injuring laser, with consequent effects on depth perception. The beliefs a soldier adopts are only partly grounded in the training he receives. Soldiers rely a good deal on informal sources of know-how and field savvy, and so training in a novel arena like laser exposure will be critical in providing the soldier a credible source of guidance that he can rely on.

Non-visual psychological effects of the use of laser protective equipment should be similar in principle to those observed with the use of chemical protective equipment. An important psychological effect of protective equipment is to increase the soldier's sense of isolation. By degrading and distorting the soldier's "view of the world," a sense of detachment from his surroundings and distance from familiar patterns of conduct are made possible. These psychological effects are particularly significant given the expected ferocity and chaos that will characterize the individual's view of the AirLand battlefield. Nothing is currently known as to how much laser protective equipment, used alone or in combination with chemical protective equipment, will contribute to this sense of isolation and thus how significant its use will be for small unit leaders. Our lack of knowledge in this area is further complicated by our inability to build perfectly reliable laser protective gear, due to the rapidly changing technology in both friendly and threat lasers.

The final suppressive effect discussed here is the least predictable. This is the effect on the medical evacuation and treatment system of soldiers seeking

medical help for minor or imaginary laser injuries, either sincerely or in an attempt to escape unpleasant duty. A useful analogy in this respect can be drawn between the future problem of laser warfare and the introduction of gas warfare in WW I. From the psychological point of view, these two technologically and temporally distant events can be seen to share some common features. First, gas warfare was something the American Army had no real experience with when the American Expeditionary Force embarked for Europe in 1917, though much thought and preparation had been devoted to it as a result of the Allied experience. Second, both gas warfare and laser exposure create the possibility of substantial injury occurring without the soldier's knowledge that he is being engaged by a weapon at all. Finally, as has been mentioned before, both chemical and laser protective equipment tends to distort the soldier's perception of the environment and to isolate him from it.

The introduction of laser technology to warfare may produce psychological effects similar to those observed in WW I. There were instances in WW I (at Bois de Belleau, with the 2nd Marine Division) where literally hundreds of soldiers flooded medical treatment facilities after a gas attack that produced only a tiny number of real casualties (6). The stress of combat can mold social forces that may alter the normative perceptions of what constitutes a legitimate illness or disability. The development of the "old sergeant syndrome" at Anzio beachhead in WW II represents another example of the medically significant effects that essentially social phenomena can have (7). In this case, experienced combat veterans came to believe that the development of battle fatigue symptoms was inevitable, and a certain social legitimacy or status was accorded veterans suffering such symptoms, when they might otherwise have received less favorable treatment from their peers. The relative difficulty of diagnosing ocular laser injuries by medical aid personnel only minimally trained and equipped for ophthalmology may, in addition, cause a certain vulnerability to malingerers, once it becomes generally known that the equipment necessary to definitively rule out laser injury is found to the rear. The prevalence of "sun-gazing" in past conflicts as an attempt to render oneself unfit for frontline duty may presage attempts by soldiers to employ military lasers for this purpose.

Exposure Effects

While we have almost no experience with the

widespread use of lasers in combat, the foregoing discussion shows that there is at least the potential for substantial psychological effects on soldiers due to their use. Cornelius Ryan, in his book The Last Battle (8), describes how the Russians amassed a huge concentration of anti-aircraft searchlights to blind and demoralize the German defenders of Berlin across the Oder River in 1945. The Russians were not very successful in this instance, but the intervening forty-two years have done much to improve the technology the Russians could bring to bear at the Oder today and little to improve the available defenses.

It seems inevitable that at least some soldiers will suffer laser injuries to their eyes. How they react will depend on at least three things: the soldiers' response to stress, the beliefs they have about laser eye injuries, and the treatment they receive after being wounded. There are vast individual differences in soldiers' response to stress (9). Some react with hysteria, others with anger, still others with depression. Laser injuries will be particularly stress-inducing for two reasons. First, vision is our primary means of relating to the world, and the fact or prospect of being deprived of it will be a source of extreme fear to anyone so afflicted. This aspect of the injury is not fundamentally different from non-laser eye injuries. A second reason that laser injuries may induce considerable stress is that, unlike ballistic eye injuries, which are often accompanied by severe wounds of other parts of the body, laser eye injuries may frequently occur alone. The laser-injured soldier may become an object of derision by his buddies if he is outwardly intact but treated as an invalid. Perhaps more importantly, a soldier with such an injury may come to feel guilty, either because he is apparently healthy but still a substantial burden to the system, or because the absence of any obvious injury may lead him or others to conclude that the injury could have been avoided.

Review of the historical record of the ophthalmology service in both World Wars produces no evidence that ocular injuries lead to unmanageable emotional responses with any great frequency, but it should be noted that the physicians who wrote the history were likely not often present at or near the time of injury. All war wounds are traumatic and frightening, and have the potential of producing shock. Knowledge, education, and proper treatment can minimize the deleterious effects of psychogenic shock.

A soldier's beliefs about laser injury prior to being wounded will shape, in large part, his immediate reactions. If he believes that any laser injury severe enough to cause symptoms will lead to permanent blindness, then he may react with more desperation than if he is more hopeful. The importance of accurate and honest training and indoctrination in this regard cannot be overstated. The following cases illustrate the powerful potentiating effects of prior knowledge.

Accident Cases

Decker, a researcher very knowledgeable about lasers and the serious effects resulting from exposure to them, was accidentally exposed to a powerful laser while working in his laboratory (10). The exposure produced an immediate vitreous hemorrhage, which Decker recognized at once as serious and perhaps permanent. He experienced a powerful emotional reaction, and in fact went into shock. A Vietnam veteran, he related that the experience of looking at the world through his own blood caused a feeling of panic and terror in him unlike anything the most grisly scene from his combat experience had produced.

PFC Johnson, a soldier quite uninformed about lasers and their effects, was accidentally exposed to a laser as he walked into a room where some buddies were playing with a laser designator. An immediate vitreous hemorrhage was also produced in this case, but Johnson had no idea what was happening. In fact, he went into the bathroom and tried repeatedly, and of course unsuccessfully, to wash the blood from his eye. It was only after several hours that he sought medical help, and only gradually and much later did he learn of the seriousness of his injury. His reaction was more subdued than Decker's, but probably would have been quite debilitating in a combat situation nonetheless (11).

The treatment that a soldier receives after he is wounded is of course extremely important in determining his emotional response to his new condition. Calm, professional treatment will be desirable but difficult given the (at least) initial confusion and difficulty associated with identifying and treating these injuries. Soldiers who sustain particularly frightening wounds, such as vitreous hemorrhages, should be assured that their wound is not life-threatening and that the chances for some recovery are good.

TRAINING IMPLICATIONS

It is clear that there is much that our soldiers need to be taught with respect to lasers. In the popular mind, lasers probably once seemed the incarnation of the "death ray" familiar to the fan of science fiction. Nowadays, the staggering diversity of laser applications, from therapeutic settings to telecommunications, from materials processing to video technology, has perhaps led to a familiarity with at least the idea of lasers as a common feature of life to most people. What should be the purposes of training the soldier with respect to lasers? And how do the psychological effects of lasers relate to the training program we might develop? As we address ourselves to these important issues, we must continually remind ourselves that lasers are only one of many threats to the soldier, and that training must not only be effective, but be seen as essential if it is to be taken seriously. Thus, laser training might become an integral part of combined-arms training in individual protective measures against the nuclear, chemical, and biological threats.

The first step in training management is to determine what the current state of knowledge about lasers and the laser threat is in the Army today. What do soldiers know about the laser threat? Do soldiers, for example, universally comply with the requirement to wear laser protection when they are at risk today? There should be ample opportunity to gather some data on this issue. Knowing this might tell us something about the validity of the threat in the eyes of the soldier.

The major focus of laser training must be to provide the soldier with the means to protect himself from lasers. This entails the exposition of what lasers are, how they can be harmful, and where we might expect them on the battlefield. While this may seem straightforward, the task is complicated by two things: first, the threat is an elusive one and in reality, little is known about what we can expect to face in the next conflict (although the Russians' attack on the Oder in 1945 suggests that restraint in the use of all available weaponry cannot be expected!). Second, understanding lasers and their effects requires a certain amount of technical knowledge. This poses a special challenge to the trainer to ensure that a highly complicated threat be portrayed in a comprehensible and accurate manner to soldiers at all levels.

What specific considerations arise from the psychological effects of lasers when we think about

training? Perhaps the key consideration is the one suggested by the Decker-Johnson dichotomy. That is, "How much knowledge is too much knowledge?" We seem to be faced with a dilemma. On the one hand, if we fail to make the risk seem real enough, soldiers may not be motivated to take defensive measures. On the other hand, if we bring lasers back to their death-ray status, we may intensify the emotional disruption they cause, perhaps to unacceptable levels.

The issue of laser training is important because psychological effects are not solely an individual phenomenon. What might we expect if we intentionally understated the risk of laser injury so as not to create excessive anxiety in soldiers? If we then found ourselves in a situation where laser injuries began to occur and soldiers realized that there was a threat that their superiors had been unaware of and been unprepared for, then perhaps the soldier's confidence in his leaders and his weapons would suffer.

On the other hand, an excessive emphasis on the laser threat and protective measures may produce soldiers preoccupied with risks from lasers to the point that their duty performance suffers. Or, if these risks are emphasized and the threat fails to materialize, how is the credibility of the leadership affected, and what effects may carry over into other areas, like nuclear, chemical and biological operations?

Finally, we need to talk about how to achieve the goals we set for ourselves on the basis of the foregoing considerations. Should there, for instance, be a laser equivalent for the dreaded gas chamber exercise that soldiers are frequently called upon to endure? Is a fundus photograph of a retinal burn or vitreous hemorrhage sufficient to arouse the soldier to genuine action in his own defense? Perhaps a series of images of the world degraded by laser effects would be a very effective training vehicle. Whatever training strategies are eventually developed, the cycle should then renew itself again with evaluation of the results.

IMPLICATIONS FOR MEDICAL DEPARTMENT RESEARCH

The discussion thus far has focused on an examination of potential or likely psychological effects of laser usage, based on a comparison of the effects of laser warfare to similar characteristics of chemical and

conventional warfare. The issue of laser training and its relation to psychological effects was discussed. Before turning to specific recommendations for research in this important, unexplored area, some general issues relating to conducting research in this area deserve consideration.

The potential psychological effects of lasers are easily discounted by the more concretely-minded among us, particularly when we are unable to adduce conclusive empirical evidence of their existence. A certain amount of skepticism is well justified. Because of the extreme lethality of the AirLand battlefield, though, we must be sure that laser warfare is not one more in a long list of factors draining the soldier's ability to fight effectively.

The fundamental problem will always be one of generalization of research results from non-dangerous experimental paradigms to real-world combat conditions. Not only do ethical considerations prohibit us from actually injuring human subjects, but they prohibit us from deceiving subjects as to the possibility of injury occurring during an experiment. Just as all pilots enter flight simulators secure in the certain knowledge that none of their number has ever perished in one, so our subjects must be made to know that there is no real risk to them in our studies. How then do we approach this problem?

Three approaches offer promise of generating useful results in this area. First, of course, is the exposure of human subjects to safe levels of laser radiation. Second, the psychological attributes that we expect to be affected by laser warfare can be manipulated by less dangerous means and the effects of these manipulations on significant tasks evaluated. Third, historical investigation and continual review of contemporary cases of laser exposure can be initiated.

The following are recommendations and opinions about research appropriate to the suppressive and exposure effects of laser technology.

Suppressive Effects

Fear. Fear in the context of combat stress has been extensively studied and reported on. Ethical considerations prohibit us from making any real empirical investigations in this area, but there is much literature to be reviewed that might provide insights.

Visual Effects of Protective Equipment. Considerable experimental effort has been devoted to the quantification of performance effects of protective equipment. While one may view this particular effect as a psychophysical rather than a purely psychological one, it is nonetheless quite germane to any discussion of this topic.

Non-visual Effects of Protective Equipment. What is militarily significant about the contribution of laser protective equipment to a soldier's level of stress on the battlefield is not the precise characterization or quantification of that contribution. Instead, the bottom line really is, "Does the addition of the requirement to wear this gear elevate the psychological stress of the soldier in combat to unacceptable levels?" Posing the question this way suggests adding the use of laser protective equipment to studies of combat stress while wearing chemical protective equipment and looking for increments in measured stress indices, or interviewing troops required to use such equipment on stressful missions.

Disruption in Visual Tasks. Performance on visual tasks may well be disrupted not by any direct visual process, but by a soldier's motivation (for example) to continue the task when it may expose him to the risk of laser injury. Studies of visual task performance when visual behavior that might reasonably be expected to lead to laser exposure is linked to negative consequences (other than actual injury!) may inform us as to the extent to which such effects might be observed under more realistic conditions. Perhaps more importantly, studies of the "ocular behavior" of subjects performing tasks under stress may help us to devise equipment or techniques that optimize the consequences of such behavior.

Effects on Medical Evacuation/Treatment. Research on this issue is perhaps best directed at identifying circumstances that may precipitate excessive "false alarm" casualty rates. Historical records and intelligence on contemporary events are most likely to shed light in this area. Some studies of the diagnosis and treatment of simulated casualties and provision of varying degrees of special training in these injuries provided to aidmen might be appropriate.

Exposure Effects

Immediate Emotional Reactions. It may well be that experimental manipulation of a reaction like shock simply is not feasible. Prior knowledge of the symptoms and prognosis of laser injuries can probably be systematically varied by instruction, but how can we test any hypotheses about post-injury outcomes? It seems likely that in the absence of actual injury data, reliance will have to be placed on currently available neuropsychiatric and medicopsychological data and historical analyses. Interviews with ophthalmologists and aidmen who served in Viet Nam and with such people from the Israel Defense Force who have recent combat experience may provide some insight into the psychological effects of ballistic or other non-laser eye injuries. A review of available information and assessment of available sources would be a logical first step in such an analysis.

Long Term Effects on Self-Esteem. The post-injury rehabilitative courses of some severely injured patients can most likely be obtained from military medical records. Past cases that resemble future laser cases on what we expect to be relevant psychological dimensions could be selected from available records, and the post-injury courses evaluated and statistically analyzed. Perhaps warning signs of severe disturbance could be noted, and appropriate interventions planned.

CONCLUSIONS

Lasers are a new dimension in battlefield lethality. While we have a great deal to learn about the prevalence of laser injuries on the AirLand battlefield, it is probable that the injury rate will be substantial. Unlike physical effects, psychological effects of lasers result from exposure as well as the possibility of exposure (suppression). The rate of physical injury will be correlated with psychological exposure effects, but suppressive effects may be considerably more numerous. Advances in protection technology, for example, might reduce the expected impact of exposure effects but increase the suppressive effects of laser employment. Thus, consideration of psychological effects must proceed as an integral part of the overall laser bioeffects program.

Quantification of the impact that the psychological

effects of lasers will have on the next battlefield is difficult, but it seems clear that this impact can be mitigated by developing appropriate training for all soldiers exposed to the laser threat. There are several promising avenues for research and training. As psychological effects are analyzed and understood, training strategies must be developed to reduce the impact of these effects on military performance.

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